



Back to Basics: A Framework for Leather Manufacture

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Dry, flat and extended leathers: Part 2

3. The role of strain within the drying cycle

4. The effects of stress within the drying cycle

3. The role of strain within the drying cycle

The setting action within samm/setting pulls out creases, provides grain flattening, and extends the wet leather. Wet leather can be readily strained, but any extension is rapidly lost upon the release of force.

As the moisture content is reduced greater stress is required to strain the leather to the required degree. This is shown in *Panel E17/6*, where the range found in samm/setting lay between 'a' and 'c'.

At lower moisture levels the deformed state is retained longer on the release of force. This is indicated in *Panel E17/7*.

If the moisture content is sufficiently low from the samming action, part of the extension gained from setting can be carried over into the drying stage. The faster the transfer from the setting to the drying operation, the greater the

Definition of terms

Elastic behaviour: When a force is applied, the material will stretch and store the applied energy. On release, the energy causes the material to return to the original form.

Plastic behaviour: When a force is applied, the material will stretch, but use the energy to deform permanently. On release, the material remains in its new configuration.

Strain: Distortion due to forces applied. Relates change in dimension to the original dimension, and for these purposes is expressed as a percentage.

Stress: Force per unit area acting on a material and tending to cause strain.

Set: Percentage residual deformation after removal of force and after a period of recovery.

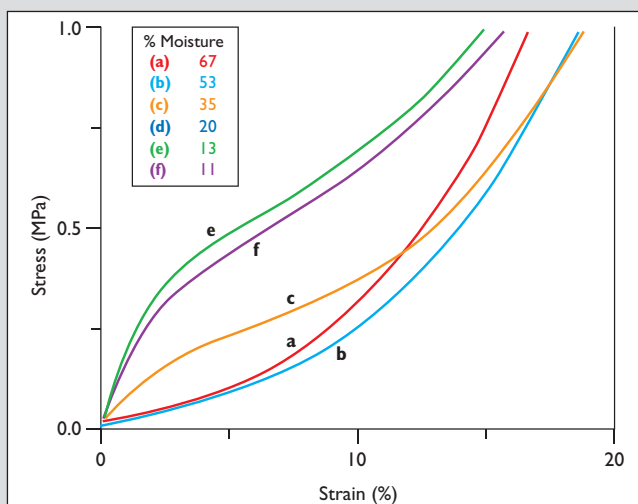
Stretch: this is a general term used when a material is extended. It does not specify extension in terms of uniformity, percentage or direction.

level of deformation that is retained.

This helps the operative in attaining the most suitable strain across the leather piece as it is offered to drying. This can range from a considerable extension in an automatic toggling unit, to suspension drying where only the residual effects from the samm/setting operation will remain.

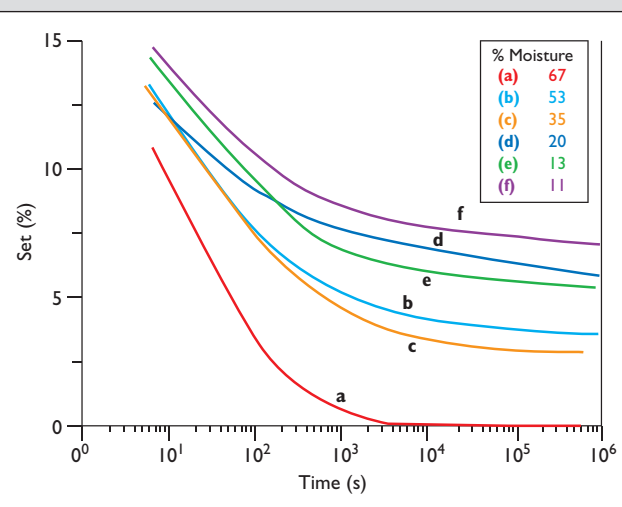
In addition, wet leather becomes more elastic at higher temperatures, so the amount of strain achieved under a given load can be improved. This applies if the leather is warm when samm/set, and when offered to hand toggle drying. It also applies when setting out on vacuum drying as heat transfers from the plate to the leather, similarly from a hot platten in a paste-drying unit. When a low moisture content is reached—and the temperature is lowered to normal levels—the deformation is complete.

Panel E17/6: Stress-strain curves for partially processed leather at different moisture contents. Samples tested parallel to the backbone.



The graph shows the increase in stress required to achieve a given level of strain as the moisture content is reduced.

Panel E17/7: Set plotted against time after release, sample tested parallel to the backbone.



The graph shows tanned leathers at rising moisture contents strained to 20%. On release of tension, the lower the moisture content, the longer the retention of set.



Where the force applied to the wet leather is high and is maintained through the drying sequence, the natural leather configuration changes. The original rounded shape of the animal is lost, and a new a flat and extended form is created. The area-yield is maximised, but this is counter-balanced as the leather becomes thinner, harder and more difficult to stretch from the new configuration.

A permanent deformation has taken place at molecular level within the peptide chain. It is believed that new cross-links are formed, and that physical bondings are developed within and between the fibres. Even if the leather is fully re-wetted then dried, the leather will largely revert to this new form. The leather gains a 'memory', and this phenomenon is indicated in *Panel E17/8*.

Only if subjected to conditions that are more severe in total than those applied in the first time drying will the leather become set into another form.

It is important to note that the details given in *Panels E17/6, E17/7, E17/8* were based on investigations using wet blue leathers. The fundamental behaviour was not influenced by dyes, retanning or softening agents. In practice, these agents are needed to moderate the final properties of the leather, however, the patterns of behaviour that are revealed remain substantial throughout leather-making.

VARIATIONS IN STRAIN ACROSS A HIDE OR SKIN

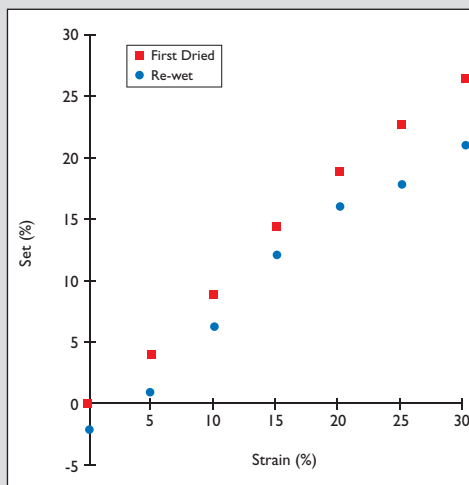
In practice, the strain achieved as a result of an applied force is not uniform across a piece of leather. The structure varies, so the less dense part of the structure—such as the belly and axillae—are extended more easily during the setting actions.

In addition, it is difficult to achieve extension of a wet hide from the centre parts towards the outer areas. When hand operations are required as the leather is set out on a vacuum drying plate or toggled to shape, there is a strong focus towards the less dense areas as they are peripheral, and naturally highly contoured.

In manual or automated toggling, considerable extension can be applied to these parts, however, the central area can remain relatively relaxed and almost free from tension. It is only when the leather begins to dry and contract that a flattening occurs in these centre parts.

These variations in strain and stress, cause shifts in properties in the different skin parts. On first consideration, it would be expected that the parts that were more

Panel E17/8: Set plotted against the strain applied during drying of leather strips.



The graph shows that the level of set achieved after completion of drying is almost the same as the strain maintained through drying. When re-wetted, then dried stress free, a considerable amount of the set is retained. This indicates the permanence of set and 'memory' that is achieved.

extended would be comparatively firm. However these areas—such as the belly and axillae—are naturally more open structured and softer. Accordingly, the outcome is somewhat counter-balanced by the inherent structural differences within each hide or skin.^[Legend 2]

4. The effects of stress within the drying cycle

From preparation to drying, throughout the drying processes and to the crust state, the fibre structure is subjected to stresses in terms of compression and extension.

FORCES OF COMPRESSION

Pressure is exerted upon the wet leather in samm/setting as part of water removal. This dewatering is useful as less energy is consumed for the evaporation of the remaining water; also the percentage strain from the setting action, which is carried forward into drying, is improved by the lower moisture content.

However, if the pressure is too great, the fibre structure is compressed to a level that does not fully allow recovery. This condition is retained through drying and, when complete, can be the cause of firm and compact leather characteristics.

Similarly, compression occurs within vacuum drying due to the pressure applied to the leather by the hood on closure. The combination of pressure, moisture and heat can readily deform the matrix into a compressed state, and this becomes more

permanent as a function of temperature and time.

This can be useful in the early stages of vacuum drying as it can help to develop a fine and compact grain surface, and improve the break characteristics. However, this gain can easily be lost, as the grain can become over-compressed. Furthermore, the free movement of the fibres deeper within the corium can be inhibited, and this results in a coarsening of the break.

FORCES OF EXTENSION

The outcome of forces that extend the leather can be seen in the level of strain achieved in the setting operation, or during manual setting in application of force. Moreover, considerable stresses are developed in leathers if they are dried in the already strained form.

In the initial phases of drying—especially toggle drying—the strain is limited to the peripheral areas, and the centre can remain stress free. As the leather dries within 2nd-Phase evaporation it begins to shrink. This can be seen as a contraction of the edge of the leather between toggle clips towards the centre part of the leather piece.

There is also a loss of water and shrinkage in the mainly tension free centre parts, but as the leather is held in place, the contraction is limited. This results in a tightening and flattening in these centre parts, coupled with a hardening of the structure. The tension increases across the whole hide, and this causes a strong re-alignment of the fibre structure into a lower angle of weave.

As discussed previously, the loss of moisture results in changes at molecular level and physical bondings at macro-scale. The temperature may rise during this stage, as chilling effects (*caused by fast evaporation*) are lost, and this leads to conditions that support a permanent deformation. The elements of temperature, moisture, strain and stress within the fibre structure are brought together in these final stages of drying. This is a major factor in the determination of leather characteristics.🌀

Legend

This subject is discussed in detail in Essay 1 of this series —“Flat and predictable leather”

Acknowledgements

E17/6, E17/7, E17/8

The influence of first time drying on the characteristics and performance of leathers: G.E. Attenburrow, British School of Leather Technology, University College, Northampton, UK: World Leather Aug/Sep 2005.